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The Use of the Spot Map in the Industrial Dispensary

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(Continued)

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THE JOURNAL OF INDUSTRIAL HYGIENE

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A DISCUSSION OF THE METHOD OF A. D. WALLER FOR COMPUTING ENERGY OUTPUT, AND RESULTS OF EXPERIMENTS DETERMINING ENERGY EXPENDITURE DURING SOME HOUSEHOLD TASKS*

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DISCUSSION

A QUICK method of measuring the energy output during work has been suggested by A. D. Waller (1), in which the carbon dioxide expired during a short period of work is measured and its caloric equivalent calculated by assuming a constant respiratory quotient. The present investigation was undertaken partly to determine how far Waller's method is permissible for approximate work, and partly to secure data on the energy expenditure in various household duties.

Both the carbon dioxide output and the oxygen intake were measured, and from these values the respiratory quotient was calculated. By the use of Lusk's table the calories per hour per square meter of body surface were computed from the caloric equivalent per liter of oxygen corresponding to the respiratory quotient actually determined.

*Received for publication July 11, 1922.

Waller contends that by the use of his shorter method a "fair" estimate can be made of various kinds of work not directly measurable in mechanical units. He contends that although an error of ± 5 per cent. is involved, his method is of value because so many more determinations can be made in less time than is required by the longer method, that the final results obtained, when taken together, are as accurate as those obtained by the longer method. He collected the expired air in rubber bags of 20 to 30 liters' capacity for periods of one-half to one minute, the bags being fitted with suitable tubing, valves, and three-way taps. Such collections of air were made at intervals of about one hour during the work. In order to save time no mask was used, but the subject breathed by mouth into the tubing, with a clip on his nose. The air was measured by a Verdin Spirometer, and the carbon dioxide estimated at once by potassium hydroxide absorption.

The first results were those of a dock laborer laying a concrete floor (2). Hourly determinations were made of the carbon dioxide discharge for half a minute immediately after work and for half a minute after three minutes' rest. From the data obtained Waller learned that an efficient dock laborer, with a resting carbon dioxide output of 5 c.c. per second, did hard work at an average cost ranging during the day between 10 and 15 c.c. of carbon dioxide per second. The values determined from the samples taken after three minutes' rest were from 30 to 40 per cent. lower than those from the samples taken immediately after the work ceased. To obtain the carbon dioxide value for a known amount of work, the subject (83 kilos in weight) made ten ascents of a 20 meter staircase, the expired air being collected for the last 10 meters of each ascent. The rate of doing the staircase work was 21.6 kg.m. per second, and the carbon dioxide output averaged 25.8 c.c. per second. As the carbon dioxide output at rest was 5 c.c. per second, the cost of doing 21.6 kg.m. of staircase work was 20.8 c.c. of carbon dioxide—*i.e.*, 1 kg.m. costs 0.96 c.c. of carbon dioxide. The cost of dock laboring averaged from 10 to 15 c.c. of carbon dioxide per second, so that the mechanical value of the work was at the rate of 10.4 to 15.6 kg.m. per second.

$$\frac{\text{10 c.c. per second}}{\text{0.96 c.c. } CO_2 \text{ per kg.m.}} = \text{10.4 kg.m. per second.}$$

Comparisons were also made of the cost of piece-work with that of time-work, by means of the carbon dioxide output in dock laborers (3). Averaging the last three hours of two complete days of each type of work, and allowing 4 c.c. per second for carbon dioxide output at rest, the cost of piece-work was found to be 20.2 c.c. of carbon dioxide per second and the cost of time-work 13.4 c.c. of carbon dioxide per second. Assuming a respiratory quotient of 0.84, for which the caloric equivalent of 1 c.c. of carbon dioxide=5.91 calories, these amounts represent 430 calories per hour for piece-work, and 284 calories per hour for time-work.

It may be well to mention here that Waller did not obtain the carbon dioxide value at rest by an actual experiment, but by allowing 1 c.c. of carbon dioxide for every 20 kg. of body-weight. In these experiments the samples were not collected during the working period, but for half a minute immediately after the work. To justify this procedure Waller determined the carbon dioxide discharge at regular half-minute intervals during and after a short piece of staircase work (1410 kg.m. in fifty-two seconds) (4). At the end of the first 10 meters the carbon dioxide discharge was 28.2 c.c. per second; at the end of the second 10 meters, 33.3 c.c. per second; and at the end of the first one-half minute of rest, 36.7 c.c. per second. The carbon dioxide value then fell, reaching the normal level in about ten minutes. From this result he concluded that since the maximum carbon dioxide discharge occurred during the first half-minute of repose, he was justified in taking his samples immediately after the work ceased.

Another experiment was made "to determine the physiological cost of marching measured by CO_2" (5). The mechanical efficiency of the subjects was estimated as before by staircase work. The marching was performed at different rates and, as was to be expected, the carbon dioxide output per second increased as the rate increased. When the subject was marching at the rate of 4 miles per hour the carbon dioxide discharge per second was 17.0 c.c.; when he

was marching at the rate of 7 to 8 miles per hour it was 51.8 c.c. From this and other experiments Waller found that the cost of horizontal walking was 0.1 c.c. of carbon dioxide per kilogram of body-weight per horizontal meter, as represented by the following equation:

$$\frac{CO_2}{\text{kg.m.}} = 0.1$$

Observations were also made with the ergometer but these will not be considered here. The efficiency of staircase work was found to be about double that of bicycle work when the rate of the former was twice that of the latter. The observations on tailors (6) and printers (7) doing various types of work are particularly interesting.

Experimental Work

Apparatus Used.—A Douglas bag was used to collect the expired air and it was shown that there was no diffusion of carbon dioxide through the bag within one and a half to two hours. The bag was connected by rubber tubing to a face mask (8, p. 590) (9), which was fitted with Douglas (mica) valves. The mask was tested for leaks before each experiment. A specially calibrated Newcomer meter (10) was used to measure the volume of air collected. The expired air was analyzed in a Haldane gas analysis apparatus.

Rest Experiments

In order to obtain the increase in energy output due to work alone, it was necessary to establish a base-line which was determined for each subject by a rest experiment before each work experiment.

The subjects were allowed to rest for ten or fifteen minutes in the laboratory before the mask was adjusted, and then for some time the expired air was caused to pass out to the atmosphere through the three-way tap. After equilibrium of respiration had been established, the three-way tap was turned so that the expired air entered the bag. The subject breathed quietly for five or ten minutes, then the tap was turned off, and the bag disconnected from the mask. The gas in the bag was thoroughly mixed so that all parts would be well washed out with the expired air, and this sample was then discarded. After the bag had been thoroughly emptied, it was reconnected and the subject breathed into it for ten or fifteen minutes. The gas was then well mixed and about one-half of it was passed through the meter. The temperature of the expired air was registered by a thermometer fitted into the inlet tube of the meter.

Before a sample was taken for analysis the bag was again thoroughly kneaded. Samples were transferred to the gas analysis apparatus by a 30 c.c. syringe, with the usual precautions to avoid errors due to dead space. All analyses were made in duplicate.

The respiratory quotient was determined from the values found for carbon dioxide and oxygen. Lusk's table (8, p. 598) (11, p. 75) for the caloric equivalent of oxygen at varying respiratory quotients was used to compute the total calories, and from this value the calories per hour per square meter of body surface were deduced.

Experiments to Check Waller's Work

Period of Collection of Sample.—In order to shorten the time required to determine the energy output, Waller collected the samples of expired air during periods of one-half minute. In order to determine what error this method might involve, we collected the expired air dur-

ing (1) one-minute periods and (2) five-minute periods. A comparison of the carbon dioxide output per second and the oxygen output per second, and the respiratory quotients for both periods are shown in Table 1. The one-minute samples were collected immediately after the five-minute samples except in the last three experiments of Table 1, and in these the five-minute samples were taken after the one-minute samples.

TABLE 1.—COMPARISON OF CARBON DIOXIDE AND OXYGEN OUTPUTS PER SECOND DURING ONE-MINUTE AND FIVE-MINUTE PERIODS, AND RESPIRATORY QUOTIENTS FOR BOTH PERIODS

One-Minute Samples				Five-Minute Samples		
CO_2 per Sec.	O_2 per Sec.	R. Q.	Condition	CO_2 per Sec.	O_2 per Sec.	R. Q.
3.80	4.30	0.903	Rest	3.09	3.54	0.874
3.02	3.51	0.860	"	3.91	3.56	0.876
2.97	3.06	0.970	"	3.36	3.68	0.913
8.43	9.28	0.908	Floor-polishing	9.53	10.34	0.915
3.27	3.69	0.888	Machine	4.02	4.55	0.883
6.73	7.35	0.915	"	6.00	6.76	0.887
6.11	7.33	0.830	"	5.42	6.53	0.831
5.58	5.93	0.940	"	3.82	4.26	0.863
4.16	4.94	0.842	"	4.02	4.05	0.883
4.05	5.46	0.742	Floor-polishing	14.21	14.70	0.957
5.62	7.54	0.745	"	10.19	11.26	0.905

The results show a marked variation in the two periods. In some experiments the amounts of carbon dioxide and oxygen are greater in the one-minute samples; in others they are greater in the five-minute samples. The variations are much too marked to say that the sample of the shorter period is representative of the composition of the expired air. Undoubtedly Waller's method would be still less reliable because in a half-minute period the error caused by turning the tap of the bag at different phases of respiration would be greater than in a one-minute period. Waller's shortened method sacrifices too much accuracy for the sake of speed, and this sacrifice we feel is not justifiable.

Samples at Beginning of Work.—In a number of his experiments Waller collected the half-minute sample as soon as work began. We performed a few experiments in which the expired air was collected as soon as work began, and compared the results with samples collected (*a*) during a later period of work, and (*b*) during a period of rest preceding the work.

In Table 2 the first two experiments show less carbon dioxide, oxygen and calories per minute, also a lower respiratory quotient for the first minute of work than for a later period of work. In the third experiment the results are much closer for the two periods. All experiments show a lower respiratory quotient during the first minute of work than during the period of rest. In a similar series of experiments Orr and Kinloch (12) obtained the same result.

Samples after Work.—In other experiments Waller collected the samples as soon as the work ceased. In the experiment with the dock laborer he found that the carbon dioxide output fell 30 to 40 per cent. during the first three minutes after the work ceased. This result led us to believe that the fall in carbon dioxide output began immediately after the work was finished. In a few of our experiments in which the expired air was collected during one minute, three minutes after the work ceased we obtained results agreeing with those of Waller. The fall in carbon dioxide output in our experiments varied from 24 to 36 per cent. (see Table 3). In other experi-

ments we collected the expired air during the first minute after work ceased. The results (see Table 4) confirmed our belief that a fall in carbon dioxide output occurs immediately on the cessation of work.

From the results given in Tables 2, 3, and 4, it is evident that Waller's method of collecting the sample at the beginning of work, or immediately after the work ceased, is quite inaccurate.

TABLE 2.—COMPARISON OF SAMPLES OF EXPIRED AIR COLLECTED DURING REST PRECEDING WORK, AT BEGINNING OF WORK, AND DURING A LATER PERIOD OF WORK

Experiment	Period	CO_2 per Min.	O_2 per Min.	R. Q.	Cal. per Min.
1	Rest	194.46	228.08	0.852	1.11
	1st min. of work	243.23	327.53	0.742	1.55
	3-8 min. of work	851.47	882.92	0.957	4.40
2	Rest	175.47	215.20	0.815	1.034
	1st min. of work	337.43	452.91	0.745	2.141
	3-8 min. of work	611.56	675.54	0.905	3.333
3	Rest	212.17	226.00	0.938	1.12
	1st min. of work	249.87	296.43	0.842	1.43
	16-26 min. of work	241.21	273.16	0.883	1.34
	1st min. *after* work	196.54	221.34	0.888	1.08

Assumed Respiratory Quotient vs. Determined Respiratory Quotient. — The respiratory quotient in our experiments varied from 0.78 to 1.04, so that considerable error would be involved by assuming, as Waller did, a respiratory quotient of 0.85 for all observations. Table 5 gives the results of our experiments in which the calories per square meter of body surface are computed (1) from oxygen at varying respiratory quotients, and (2) from carbon dioxide at a constant respiratory quotient of 0.85. Comparing the results in Table 5, it will be noticed that the variation in the last two columns is least when the respiratory quotient actually determined is closest to the respiratory quotient of 0.85 assumed by Waller. The variation in the two methods is even more evident in a short series of experiments in which the same subject did the same piece of work on two days. The results are computed as before (1) from oxygen at varying respiratory quotients, and (2) from carbon dioxide at a constant respiratory quotient. It will be seen from Table 6 that the variation in the caloric output for the two days is always greater when the results are computed according to Waller's method. This table shows that in these experiments the method of calculating from oxygen is 10 to 11 per cent. more accurate than Waller's method.

TABLE 3.—FALL IN CARBON DIOXIDE OUTPUT THREE MINUTES AFTER WORK

Work	Per Cent. CO_2 during Work	Per Cent. CO_2 3 Min. after Work	Per Cent. Fall in CO_2
Staircase	4.25	3.10	27.15
Machining	2.90	1.85	36.20
Ergometer	3.95	3.00	24.05

TABLE 4.—FALL IN CARBON DIOXIDE OUTPUT IMMEDIATELY AFTER WORK

Work	Per Cent. CO_2 during Work	Per Cent. CO_2 after Work	Per Cent. Fall in CO_2
Staircase	4.35	3.80	12.60
Machining	3.50	3.05	12.80
Floor-polishing	3.70	3.40	8.11

Efficiency Experiments

In order to determine the efficiency of a subject it is necessary that a known amount of work should be done. For this purpose two types of experiments were performed: (1) staircase, and (2) ergometer.

Staircase Experiments.—As far as possible Waller's method was followed (*i.e.*, collecting the sample of expired air during the last half of each ascent, and calculating the efficiency from carbon dioxide). A metronome was used to keep the rate of walking constant. The work done was five ascents of a 10-meter staircase, but the tap was turned to the bag only during the last half of each ascent—*i.e.*, the sample was collected during five ascents of 5 meters. The caloric value of the work done was determined by using the value, 1 calorie=425 kg.m. The cost of work in calories was obtained by subtracting from the caloric expenditure during work the caloric expenditure during rest for the same period. The ratio

$$\frac{\text{work}}{\text{cost}} \times 100 = \%\ \text{efficiency.}$$

Ergometer Experiments.—A bicycle ergometer (13) was used, the work done being measured by the number of revolutions of the wheel per minute × the circumference of the wheel × frictional pull. The subjects used different rates, but the rate for each experiment was kept constant during the preliminary period of three minutes, and during the experimental period of five minutes.

Table 7 gives a comparison of our ergometer and staircase experiments. The calculations were made according to Waller's method—*i.e.*,

$$\frac{\text{work}}{\text{cost}} = \frac{\text{kg.m. per second}}{\text{net } CO_2 \text{ per second}}.$$

The results agree with his. Results (1), (2), and (3) in the ergometer table represent the work done at three rates—60, 84, and 104 steps per minute, respectively. They show that as the rate of work increases the ratio $\frac{\text{work}}{\text{cost}}$ increases —*i.e.*, efficiency increases. Comparing (4) in the ergometer table with (1) in the staircase table, it is seen that work done on the staircase at twice the rate of the work done on the ergometer (10.04 kg.m. per second vs. 5.5 kg.m. per second), gives a higher $\frac{\text{work}}{\text{cost}}$ ratio; (5) and (6) in the ergometer table compared with (2) in the staircase table show the same result. If (7) in the ergometer table is compared with (1) in the staircase table, it is seen that when the rate of work on the staircase and on the ergometer is the same, the efficiency in doing staircase work is again higher.

Table 8 gives our results for staircase and ergometer experiments computed by Benedict's method.[1] The experiments are in the same order as in Table 7. Table 8 includes two additional experiments in both types of work. From (1), (2), and (3) it is seen that the efficiency increases as the rate of work on the ergometer increases (this is shown in column $\frac{a}{b-c} \times 100$). Comparing the ergometer table with the staircase table, it is seen that when the caloric value of the work done is approximately equal for both kinds of work, the efficiency in doing the latter is always greater than the efficiency in doing the former. If (4) in the ergometer table is compared with (2) in the stair-

[1]Benedict's method (11, p. 112) of computing the net efficiency of a subject is as follows:

$$\text{Net efficiency} = \frac{\text{Heat equivalent of muscular work done}}{\text{Increase in energy due to work}}$$

$$= \frac{a}{b-c} \times 100$$

a = heat equivalent of work done (1 calorie = 425 kilogrammeters).
b = total caloric output for period of work.
c = resting requirement in calories for similar period.

TABLE 5.—RESULTS OF EXPERIMENTS IN WHICH CALORIC OUTPUT WAS COMPUTED FROM OXYGEN AT VARYING RESPIRATORY QUOTIENTS, AND FROM CARBON DIOXIDE AT A CONSTANT RESPIRATORY QUOTIENT

Work	Net CO_2 per Sec.	Net O_2 per Sec.	R.Q.	Cal. per Hr. per Sq. M. from O_2	Cal. per Hr. per Sq. M. from CO_2 (R.Q. 0.85)
Bread-making	2.37	1.17	1.000	14.44	33.30
	3.65	3.48	1.040	42.42	55.07
	1.90	2.56	0.836	27.09	24.29
	4.07	4.80	0.896	56.38	57.25
	3.48	3.77	0.918	49.60	54.39
	1.95	2.11	0.875	22.23	27.43
	1.41	1.53	0.940	16.24	17.71
Machining	3.71	1.05	0.807	10.94	9.36
	2.95	2.76	1.020	35.66	44.46
	0.48	0.78	0.883	8.68	6.80
	2.06	2.84	0.831	30.19	27.17
	0.32	0.40	0.895	4.64	4.51
	1.00	1.28	0.863	13.45	12.57
Floor-polishing	1.08	1.48	0.882	16.29	14.24
	6.44	6.80	0.915	76.57	84.92
	1.66	2.14	0.869	26.22	25.02
	10.95	10.91	0.957	123.27	144.40
	7.26	7.67	0.905	85.99	95.74
	5.73	6.19	0.910	68.90	75.56

TABLE 6.—VARIATION IN CALORIC OUTPUT DURING TWO DAYS' WORK COMPUTED FROM OXYGEN AT VARYING RESPIRATORY QUOTIENTS, AND FROM CARBON DIOXIDE AT A CONSTANT RESPIRATORY QUOTIENT

Work	CO_2 per Sec.	O_2 per Sec.	R.Q.	Cal. per Hr. per Sq. M. from O_2	Cal. per Hr. per Sq. M. from CO_2 (R.Q. 0.85)	Variation in 2 Days' Work: O_2 Method %	Variation in 2 Days' Work: CO_2 Method %
Machining	2.45	2.85	0.887	31.72	32.31	5.0	16.0
	2.06	2.84	0.837	30.19	27.17		
Walking	6.53	8.28	0.835	90.43	86.11	6.4	16.5
	7.61	8.79	0.876	96.24	100.35		
Floor-polishing	7.03	8.51	0.825	92.43	92.71	25.0	36.0
	10.95	10.91	0.957	123.27	144.40		

TABLE 7.—COMPARISON OF RESULTS OF ERGOMETER AND STAIRCASE EXPERIMENTS COMPUTED BY WALLER'S METHOD

Ergometer			Staircase		
Kg.M. per Sec.	Net CO_2 per Sec.	Kg.M. CO_2	Kg.M. per Sec.	Net CO_2 per Sec.	Kg.M. CO_2
(1) 9.90	13.66	0.724			
(2) 13.86	13.21	1.040			
(3) 17.16	11.80	1.450			
(4) 5.54	11.59	0.478	(1) 10.04	8.85	1.13
(5) 6.60	12.23	0.543	(2) 13.90	12.64	1.09
(6) 6.60	11.47	0.575	(3) 19.06	17.13	1.11
(7) 10.56	12.91	0.817			

TABLE 8.—COMPARISON OF RESULTS OF ERGOMETER AND STAIRCASE EXPERIMENTS COMPUTED BY BENEDICT'S METHOD

Ergometer					Staircase				
	a	b	c	$\frac{a}{b-c} \times 100$		a	b	c	$\frac{a}{b-c} \times 100$
(1)	4.19	18.12	3.51	28.67					
(2)	5.87	16.00	3.24	46.00					
(3)	7.26	13.48	3.57	72.25					
(4)	1.56	9.34	2.06	21.42	(1)	1.06	2.82	0.92	55.79
(5)	4.66	24.63	4.76	23.45	(2)	2.94	5.66	1.86	77.37
(6)	4.66	23.64	6.18	26.69	(3)	4.03	7.10	1.92	77.79
(7)	4.47	14.23	3.09	40.12	(4)	4.03	8.35	2.47	68.53
(8)	4.80	13.26	3.09	47.19	(5)	1.27	2.78	0.54	56.69
(9)	2.60	14.96	2.06	20.23					

case table, it is seen that the efficiency in performing staircase work is also higher even when the caloric value of the work done is approximately twice that of the work done on the ergometer. These results agree with those obtained by Waller's method, but Benedict's method is considered much more accurate since it involves the use of the determined caloric output and not merely the use of the carbon dioxide determination.

TABLE 9.—RESULTS FOR HORIZONTAL WALKING EXPERIMENT COMPUTED BY WALLER'S METHOD

	Kg.M. per Sec.	Net CO_2 per Sec.	$\frac{CO_2}{\text{Kg.M.}}$
(1)	64.81	6.95	0.107
(2)	82.69	7.61	0.092
(3)	83.35	6.53	0.078
(4)	67.54	6.90	0.102
(5)	67.53	6.06	0.089

TABLE 10.—RESULTS FOR HORIZONTAL WALKING EXPERIMENT COMPUTED BY BENEDICT'S METHOD

	Body-Wt. (Clothed+Bag)	Distance per Min.	Horizontal Kg.M. per Min.	Total Cal. per Min.	Heat Output Increase over Sitting Total Cal. per Min.	Heat Output Increase over Sitting Per Kg.M. in Gm.=Cal.
(1)	50.00	77.77	3888.88	3.31	2.43	0.625
(2)	64.30	77.14	4960.20	3.73	2.56	0.516
(3)	64.30	77.77	5001.11	3.55	2.41	0.481
(4)	46.31	87.50	4052.12	3.59	2.48	0.612
(5)	46.31	87.50	4052.12	2.32	2.18	0.537

Horizontal Walking Experiments.—The subjects walked a distance of 700 meters at a uniform rate. In order to check Waller's method the work done was calculated by the distance in meters × the body-weight in kilos. It was also determined by measuring the total caloric output, as recommended by Benedict (14).

In Table 9 our results for the horizontal walking experiment have been computed by Waller's method. In Table 10 the results have been computed by Benedict's method without taking into account, however, the energy expenditure due to the lifting of the body-weight at each step.

By comparing the last column in Tables 9 and 10 it is seen that the cost of horizontal walking, either in cubic centimeters of carbon dioxide per kilogrammeter, or in gram calories per kilogrammeter, does not agree with Waller's conclusion that the $\frac{\text{cost}}{\text{work}}$ ratio is a constant (0.1). In both tables numbers (2) and (3), and (4) and (5) are, respectively, the results of a subject doing the same amount of work at approximately the same rate. It will be seen that the cost of work is not constant even for the same individual, and that Waller was not correct in claiming that there is an increase of 0.1 c.c. of carbon dioxide per kilogram per horizontal meter.

Energy Expenditure during Some Household Tasks.—The household tasks which were performed to obtain data were bread making, machining, and floor-polishing. The results of the energy expenditure during these tasks are of interest.

In the bread-making experiments the cost in calories per hour per square meter varied from 14.44 to 56.38 calories. The average cost for eight experiments was 33.53 calories, with an average variation of ±13.52 calories. Every experiment was done by a different subject.

The rate of machining varied from 52 treads per minute to 124 per minute,

and the energy expenditure varied accordingly, being 4.64 calories when the rate was 52 treads, and 30.95 calories when the rate was 124. In ten experiments the cost per hour per square meter averaged 16.05 calories, and the average variation was ±9.72 calories.

The floor-polishing experiments were done at rates which varied from 30 to 75 strokes per minute. The cost per hour per square meter at the rate of 30 strokes was 11.98 calories, and at the rate of 75, 68.9 calories. The length of the stroke for the experiments at the rate of 50 strokes was double that used in all other experiments, and as a result the cost at that rate was even higher than at the faster rates. Averaging all the experiments (eleven), the cost in calories per hour per square meter was 48.86 calories, the average variation being 25.06 calories.

Conclusion

From these results it seems fair to conclude that Waller's method of computing the energy output from the carbon dioxide expired would be useful in saving time, but it does not give accurate results, and is therefore unsatisfactory. The short periods which he used for collecting the samples of the expired air, and the method of collecting the samples at the beginning of the work and after the work was finished, all involved serious error. It is also evident from our results that it is essential actually to determine the respiratory quotient in all experiments, and to compute the energy output by means of the caloric equivalent of oxygen for the quotient obtained.

Waller's method of ascertaining the efficiency of the subject is also considered inaccurate because it is not based on the caloric output.

In conclusion, we feel that Waller's short method of computing the energy output is of little value, since it disregards so many factors essential for accurate determinations.

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THE USE OF THE SPOT MAP IN THE INDUSTRIAL DISPENSARY*

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FOR several years epidemiologists and sanitary engineers have used spot maps to help them analyze the health conditions in given communities. During the Salem, Ohio, typhoid epidemic of 882 cases,[1] the state epidemiologists had a map of the entire city prepared, showing the location of every house in the city. Whenever a case of typhoid developed, a colored tack was placed in the proper space on the map. Differently colored tacks were used to represent different weeks, so that not only the actual number and distribution of cases could be seen at a glance, but also the matter of contact infection could be easily checked.

We have borrowed this idea and have used it to aid us in keeping a daily check upon the health conditions in our plant. By means of the spot map a picture is constructed which enables one to visualize, almost at a glance, a situation which pages of written reports fail to make clear. This procedure has been of such value that we offer it for publication in the hope that others may benefit by it. It is, in fact, quite simple; all that is necessary is a floor plan of the factory showing the location of each operator and a set of six or eight differently colored tacks.

MODUS OPERANDI

If an operator comes to the dispensary and is found to be suffering from tonsillitis, a red tack is at once placed upon the map in a position corresponding with her location in the factory. If her case is severe, the operators working near her are given a gargle. Meantime the map is watched closely to see whether other cases of tonsillitis develop in the same department.

A blue tack is used to denote a case of coryza, or nose cold; a green tack indicates bronchitis, a yellow one, contagious skin lesions such as scabies and impetigo; a brown and white plaid one, influenza or grip; and a red and black plaid one, enteritis. A green tack with a black cross (the cross drawn with pen and ink) denotes the absence of an employee on account of illness. If the nature of the illness is known, the tack denoting that particular disease is placed with the absentee tack. A red tack with a black dot in the center means an accident. It is surprising to see the number of tacks of this sort on the charts from some departments. This particular finding may aid the safety committee in reducing the number of accidents to a minimum.

One of the most valuable tacks is the pink one, which represents headache from all causes. On several occasions, by watching the increasing number of headache tacks in one department, we have discovered lack of attention to ventilation.

During the last grip epidemic we tried to send operators who were coming down with the disease away from the plant at the earliest possible moment. Prophylactic treatment (consisting of a gargle

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[1] Bunn, W. H.: The Salem, Ohio, Typhoid Epidemic: A Clinical Report. Jour. Am. Med. Assn., 1921, 76, 1159.

and nose pack of a camphor-menthol compound) was then given to all the employees who had been in contact with them. An effort was made to surround every grip tack on the board with a yellow cross tack (a yellow tack with a black cross drawn on it with ink stands for prophylactic treatment in this system). The ease with which contagious

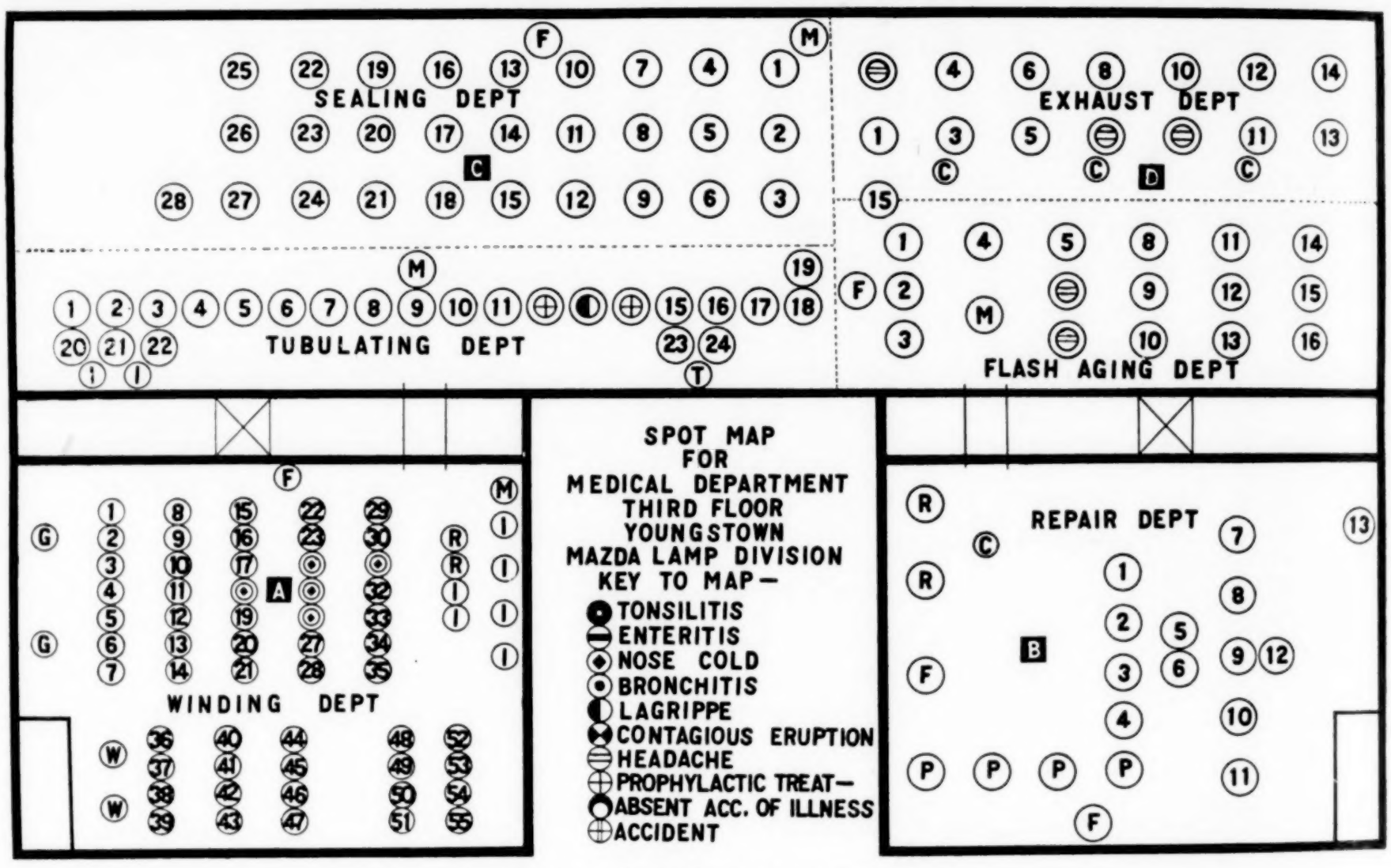

FIG. 1.—Sample spot map.

usual situation shows just how infectious an acute nose cold can be. The condition would probably have been overlooked, had not the spot map been in use. The operator just opposite the letter A was the first to report. The adjoining operators developed nose colds within a few days.

In Department D there were several cases of headache on successive days. An investigation of this condition, which was first noted on the spot map, revealed the fact that the ventilating system was not functioning properly.

The grip and prophylactic tacks placed in Department C illustrate the method of trying to prevent the spread of disease by the use of prophylactic measures and the advantage of using the spot map for this purpose. Operator Number 13 developed grip, and operators 12 and 14 were given prophylactic treatment.

cases were kept in mind, and the faithful prophylactic work of the dispensary nurse, we believe, accounted for the low incidence of grip in our factory—an incidence much lower than that of some other institutions in this vicinity.

In order to illustrate some of the uses of the map, the diagram shown in Figure 1 has been prepared. For convenience in photographing, however, designs have been substituted for colors.

It will be noted that in Department A there are several cases of coryza all grouped around a central one. This un-

Removal Record

To prevent the tacks from accumulating on the board, a removal record, such as that shown in Figure 2, is used. This consists of a sheet of ruled paper on which is kept the serial number of the

No.	Date	Dept. No. and Initial	Color	Removed
211	2/10/22	A18—M. S.	Blue	2/24/22
212	2/11/22	D7 —S. I.	Pink	2/18/22

Fig. 2.—Tack removal record.

case, the date that the tack was placed on the board, the initial or number of the operator's machine, the color of the tack, and the date that the tack is to be removed. The tacks denoting contagious conditions are left on for a fourteen-day period. The headache and accident tacks are left on for one week.

When the removal-record sheet is filled, a new one is attached to the map and the old one is filed. This constitutes a permanent record which can be used for statistical purposes at any time.

Summary

The spot map can be used to advantage in an industrial dispensary for the following reasons:

1. It visualizes the health situation.
2. It is of value in checking the spread of infectious diseases.
3. It supplies valuable accident information to the safety committee.
4. It makes a permanent record for statistical purposes.

A CLINICAL STUDY OF FUR CUTTERS AND FELT HAT WORKERS*

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ONE hundred and eight hatters' fur workers and felt hatters were examined in Danbury, Connecticut, in the autumn of 1921. Public announcement was made of the opportunity for medical examination, and all the workers who presented themselves were examined without selection. With few exceptions they were men actively engaged at their respective trades, and few of them considered themselves notably diseased.

For the purposes of this analysis of findings, the examination records of eight persons have been eliminated; six of them had been employed for less than two years, one was a young apprentice, and the record of another was incomplete. There are available, accordingly, the results of 100 fairly complete physical examinations. In addition, twenty-seven urine analyses were made, and subsequent to the examinations radiographs of the chests of fifty-six members of the group were obtained.

Representatives of thirty fur or hat shops were found among the 100 men, twenty-two of whom constituted the largest single shop contingent.

Occupation.—Eight men were hatters' fur workers, four of whom were engaged in carrotting, the others doing cutting, clipping, plucking or shaving. Sixty-nine worked in the "back shops" of hat makers' establishments, distributed among the following trade processes:

Blowing	1
Coning	6
Hardening	2
Starting	3
Sizing	48
Dyeing	1
Blocking	4
Pouncing	2
Napping	1
Velouring	1

Twenty-three were "front shop" finishers. Many of the men had been employed previously at other processes than those of their recorded occupations.

Nationality.—Of the 100 men, twenty-six were native born of native parentage. Fifty-seven were foreign born; of this number fifteen were born in Ireland, seventeen in Austria-Hungary, Czecho-Slovakia, or Poland, eight in Italy, seven in Syria, five in Germany, and five in other countries. Seventeen were native born of foreign parentage, for the greater part either Irish or Italian.

Age and Duration of Service.—The men ranged from 23 to 67 years of age, and had been employed in the hatting industry for periods varying from two to forty-seven years. They were distributed as follows with respect to age and to duration of service:

Age Distribution

Years	No.
20-29	18
30-39	36
40-49	23
50-59	13
60 and over	10

Distribution with Respect to Duration of Service

Years	No.
2 to 3	4
3 to 5	12

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Years	No.
5 to 10	12
10 to 15	13
15 to 20	20
20 to 25	15
25 to 30	4
More than 30	20

It may be noted that 72 per cent. of the group had been employed in the industry for more than ten years, 39 per cent. for more than twenty years, and 20 per cent. for more than thirty years.

Medical History.—Little information of value was secured regarding the medical histories of either the members of the group or of their families. Two instances of family tuberculosis were recorded, and several men had had typhoid fever or malaria. All but nineteen denied having had venereal disease. Of this number, one admitted having had syphilis.

Ninety of the group used tobacco, many of them in considerable amounts. Chewing was especially prevalent. Twenty-one stated that they had not drunk alcoholic beverages, but of the remaining seventy-nine many frankly admitted habitual excessive drinking. Fifty men drank coffee; ten drank tea.

Appearance.—The general appearance of most of the members of the group was good. Sixty-nine were rated as of good nutrition; twenty-five, fair; and six, poor. Few of the men were emaciated, and most of them were of approximately normal weight.

Skin.—The color of the skin was good in eighty-one of the men, and fair in seventeen. Two men were distinctly pallid. No hemoglobin determinations were made. Skin eruptions were negligible. There were observed among the sizers, however, deep indurated calluses of the hands extending from the thenar and hypothenar eminences over the palms and to the finger tips. In many instances the hands were stained by dyes used in the sizing kettles. Eighteen men, sixteen of them sizers, showed marked calluses of the type described. Six sizers had developed Dupuytren's contractions, usually of the little finger of one or both hands. A flanger and a curler had similar disabilities.

Special Senses.—According to the statements of the individuals examined, vision was highly deficient in but few instances. Forty of the men wore glasses, especially for reading. The pupillary reactions were not remarkable.

Partial deafness was recorded in eighteen cases, and a history of running ears in ten. Thirty-three persons complained of tinnitus, though few were affected constantly. There was no notable evidence of diminished olfactory sense.

Teeth.—The teeth of most members of the group were in fair condition. Twenty-eight men stated that they had occasional or frequent toothache. In but rare instances was there evidence of extensive dental disease with loosening of the teeth. Many men had lost several molars, five wore plates in both jaws, and three in one jaw only. Marked discoloration of the teeth was noted in a few cases.

Gums.—Pyorrhea was observed in forty-five persons, occasionally with readily bleeding gums. There were but two cases of gingivitis so marked as to suggest some disease other than pyorrhea. For the purposes of this study no attempt has been made to differentiate between gingivitis and the inflamed gums associated with pyorrhea.

In three men there was observed a definite "blue line" in the gums, somewhat similar to the Burtonian line of lead poisoning. The markings were dis-

tinctly punctate, blue-black in color, and finer than those commonly seen in cases of poisoning by lead. No conclusive evidence of lead absorption was obtained. One of the three men was a coner, the other two were sizers.

Mouth and Throat.—Twenty-two persons gave a reasonably trustworthy history of salivation, usually very moderate in degree; only three showed salivation when examined.

Twenty-five men were recorded as having a sensation of dryness of the throat; eighteen, a sensation of tickling. Eleven had sore tongues. Eighteen admitted having, upon occasion, noted a metallic taste, though reliable information regarding this matter was difficult to obtain.

Coated tongues were observed in twenty-six of the group, throats of dry appearance in six, and dusky mucosae in nineteen. Light patches on mucous membranes were observed in but two cases. No noteworthy odor of the breath was reported. Five men had slight speech defects.

Lymph Nodes.—Slight or moderate general adenopathy was recorded in thirty-six instances.

Cardio-Respiratory Symptoms.—Respiratory infections were reported as common. Forty-nine individuals gave a history of frequent colds, sixteen of pneumonia, eighteen of pleurisy, forty-nine of frequent coughs, and nine of hemoptysis. Statements regarding fever were untrustworthy.

Examination of the lungs disclosed various positive findings in thirty-two cases, for the most part signs of chronic bronchitis or of old pleuritis. Patches of dulness with increased fremitus and coarse râles were occasionally encountered. No case of active tuberculosis was recognized.

X-ray examination of a portion of the group not specially selected showed numerous cases of marked hilus infiltration, diminished radiance of one or both apices, numerous soft glands, and occasionally diffuse mottling. The following case reports are cited by way of illustration:

Case 7.—This man, aged 54, had been employed as a shaver for seventeen years. Physical examination of the chest was negative; X-ray examination showed coarse mottling scattered throughout both chests. Both apices were dull.

Case 15.—This man was 48 years old and had been employed as a finisher for fifteen years. Physical examination showed slightly impaired resonance; X-ray examination showed hilus infiltration, coarse peribronchial thickening, mottling throughout the entire right chest and upper lobe. The right apex was distinctly dull. The findings resembled tuberculosis.

Case 58.—This man, aged 62, had worked as a mixer in the blowing room for thirty-three years. Physical examination of the chest was negative; X-ray examination showed marked hilus infiltration, increased soft glands, and mottling scattered throughout both chests. The left upper lobe was distinctly dull. The findings resembled tuberculosis.

Case 60.—This man, aged 26, had been a starter for eight years. Physical examination of the chest disclosed dulness of the left upper lobe; X-ray examination showed marked hilus infiltration extending throughout both chests, and fine scattered mottling.

Broadly speaking, the radiographic findings, while in certain instances offering evidence of dust inhalation, were not notably distinguished from those ordinarily obtainable upon the examination of any group of men of like ages and numbers.

Twenty-two individuals gave a history of some degree of dyspnea; twenty-seven complained of palpitation; six appeared cyanotic; and fifteen were slightly or moderately edematous. Examination of the heart in ten cases revealed

evidence of disease, particularly hypertrophy and dilatation. Thirty-nine persons had a systolic blood pressure exceeding the age plus 110, the average excess over age plus 110 being 14.4 (mm. Hg). The average pulse pressure was 56.4 points. The age distribution of the members of this group was as follows:

Age Years	No.	Av. Excess over Age plus 110	Av. Pulse Pressure
20-29	7	14.0	46.4
30-39	18	10.7	52.5
40-49	6	23.5	68.5
50-59	5	8.6	60.0
60 and over	3	28.6	74.0
Total	39	14.4	56.4

Kidneys.—Of twenty-one specimens of urine obtained from these thirty-nine persons, five showed albumin. Fifty-eight men from the entire group of 100 reported nocturia. A definite history of hematuria was obtained in but one instance, associated with evidence of renal colic.

Gastro-Intestinal Findings.—No abnormal masses were found upon abdominal examination. Five persons were found to have inguinal herniae.

It is noteworthy that but one person complained of lack of appetite. Thirteen believed their digestion to be poor. Twenty-one were constipated. Ten reported occasional diarrhea. Hemorrhoids were noted in sixteen instances. Abdominal pain or distress was not strikingly manifest, and in the majority of the fifteen cases recorded the pain was in the epigastrium.

Posture.—The posture of approximately half of the men examined was exceedingly poor, the attitude being characterized by marked lumbar lordosis. Flattened chests and pendulous abdomens were frequently observed.

Neuromuscular Findings.—Thirteen men suffered from headache occasionally or frequently, sixteen others but rarely. No characteristic localization was apparent. Forty-three individuals stated that they were subject to attacks of dizziness, which in many instances was said to be marked.

Of twenty-six persons who complained of pain in the arms or legs, nine suffered from pain in the forearm, the hand, or the finger joints. In many cases the pain was presumably related to arthritis. Nineteen gave a history of tingling, numbness, or formication, usually of the fingers and hands. Of these, fourteen were sizers, two were blockers, one a wetter down, one a cutter, and one a blower. One dyer complained of itching legs.

Twenty-six of the men had had neuralgic pain, localized, for the most part, in the jaw or the cheek, and doubtless related in many instances to dental infection.

Tremors were observed in so many instances that particular care was exercised in the differentiation of degrees of tremor. The muscles of the face or orbits showed a slight or moderate tremor in seventeen cases. In thirty cases tremor of the tongue was recorded, in twenty-two of which it was slight. Tremor of the fingers, usually fine, was present in fifty-five cases, slight in twenty-eight, and moderate or marked in twenty-seven. Intention tremor of the fingers was observed in thirty-one persons, in twenty-two of whom it was moderate or marked, in nine slight. There were six additional doubtful cases.

Fibrillary twitchings of various muscles were reported in twenty-five cases, in seventeen of which they were moderate or marked. Evidence of this condition was, however, unsatisfactory in many instances.

Tremor of the muscles of the orbit alone was observed in three cases; of the tongue alone in three cases; of the fingers alone in twenty-four cases; of the muscles of the orbit and of the tongue in two cases; of the orbit and of the fingers in six cases; of the tongue and of the fingers in nineteen cases; of the orbit, tongue, and fingers in six cases.

The power of the flexor muscles of the forearms was estimated as fair in eleven cases, and as poor in but two cases; while the power of the extensor group was considered fair in thirteen cases, and poor in five.

Knee jerks were not obtained in four cases, and apparently were diminished in four others. One positive Romberg test was observed.

Insomnia was noted with considerable frequency. Thirty-three men had difficulty in sleeping. Several complained only of restlessness, while many others could not sleep for a few hours after going to bed, or wakened early and could not fall asleep again.

Thirty-nine complained of excessive fatigue. In recording these cases an effort was made to exclude reports of ordinary weariness. Numerous circumstantial details indicated that certain persons were finishing the day's work with little or no reserve energy. A history of night blindness was obtained in four cases.

Thirty-four men admitted, on careful questioning, that they were frequently discouraged and "blue." It was, of course, difficult or impossible to distinguish the mental depression resulting from the relative inactivity of industry from that possibly of toxic origin. One man did not wish to see anyone when depressed, and another felt blue and "would like to be dead instead of alive."

Fifty-nine members of the group considered themselves as abnormally nervous and irritable. In many instances this irritability was attributed by the men to the presence of strangers, to the necessity for unusual work, or to anger. The character of the nervous reactions is perhaps best exemplified by the statements of some of the men themselves.

CASE 4.—"I 'fraid for boss, 'fraid boss gimme hell!"

CASE 16.—"Sometime mek me mad, I look lak a crazy."

CASE 17.—"If anybody ask me to do something quick, I shake."

CASE 30.—"Gets worse if I'm watched." He would slow up, if watched at work.

CASE 41.—This man became nervous, trembled, and stopped work as soon as a stranger came in. He also felt weak in his knees.

CASE 50.—"Feels sometimes as if I had done something wrong, as if somebody was after me." When he gets excited "then can't talk hardly at all." He becomes nervous if he is watched, and his legs "starta wiggle."

CASE 54.—"Gets all thumbs."

CASE 103.—"If I'm watched I seem to lose control of myself—don't do the work as I ought to do it—as well as I could do it. I get the idea that someone is looking at me when no one is. Feel as though I'm ready to fly."

Mercury Poisoning.—In discussing mercury poisoning among felt hatters many authors have emphasized the importance of salivation, dryness of the mouth, gingivitis, a blue line in the gums, tremors, and psychic irritability.[1] In the course of the clinical study, the results of which are here presented, these six symptoms or signs were recorded with the following frequency: salivation, 22; dryness of the mouth or throat, 25; gingivitis (with pyorrhea), 45; blue line, 3; tremors, 61; psychic irritability, 59.

[1] See Hamilton, A.: Industrial Diseases of Fur Cutters and Hatters. THIS JOUR., Sept., 1922, 4, No. 5, 219.

Of the 100 men examined, there were fifty-three who presented at least two of the above six signs or symptoms. There were other cases in which either a tremor, or marked salivation, or a blue line was noted, such suggestions of possible mercurialism, however, lacking supporting evidence. Of the fifty-three cases, ten have been eliminated as questionable for various reasons, such as uncertainty regarding the severity of psychic disturbance or tremors. The remaining forty-three cases showing quite definite signs of mercurialism were classified according to trade process, age, and experience as follows:

Process	No.	% of All Similarly Engaged	Av. Age *Years*	Av. Duration of Service *Years*
Fur Workers	*3*	*37.5*	*26.6*	*2.6*
Plucking	1	100.0	34.0	2.0
Carrotting	1	25.0	23.0	3.0
Cutting	1	100.0	23.0	3.0
Back Shop	*31*	*44.9*	*42.0*	*19.8*
Blowing	1	100.0	62.0	33.0
Coning	3	50.0	38.3	15.6
Hardening	1	50.0	43.0	25.0
Starting	1	33.3	26.0	8.0
Sizing	20	41.6	42.3	20.6
Blocking	3	75.0	46.3	26.6
Napping	1	100.0	33.0	16.0
Velouring	1	100.0	39.0	4.0
Finishing	*9*	*39.1*	*53.5*	*29.2*
Total	*43*	*43.0*	*43.3*	*21.2*

Among the group of forty-three cases with definite signs of mercurial poisoning, salivation was noted in seventeen, dryness of the throat in eight, pyorrhea or gingivitis in twenty-one, a blue line in two, tremor in forty, and psychic irritability in thirty-seven. Fourteen cases presented two of the symptoms, usually tremor and psychic disturbance; twenty cases presented three of the symptoms, usually tremor, psychic irritability, and gingivitis; eight presented four of the symptoms; and one case presented tremor, psychic irritability, salivation, gingivitis, and a blue line.

Eighteen of the forty-three men had abnormally high blood pressure. Urine analyses in thirteen of the eighteen cases revealed albumin in but four instances. Edema, usually of the ankles, was noted in ten cases of the group of forty-three, associated with high blood pressure in six persons, and with albuminuria and hypertension in two. In seven cases there was fairly frequent diarrhea.

Ten of the group of forty-three men had sore tongues, associated with salivation in three cases. Of twelve who had noted a metallic taste, seven also gave a history of salivation. In four additional cases the history of metallic taste was inconclusive.

In fourteen cases there was a suggestion of weakness of the muscles of the forearms, especially of the extensor group. In no case was there marked paresis. Thirteen men complained of numbness, tingling or itching, particularly of the fingers. Sixteen gave a history of twitching muscles, most often noted when in bed. Thirteen reported pain in the extremities, especially in the joints of the hands and arms, or in the knees.

Twenty men gave a history of discouragement, twenty-one of attacks of dizziness, and nineteen of insomnia. Psychic irritability, observed in thirty-seven cases among the group of forty-three, was associated with discouragement in twenty of these cases, with dizziness in twenty cases, and with insomnia in fifteen cases.

Of the forty-three men who, it may be assumed, presented evidence of mercurial poisoning, five should be considered as severely affected, fourteen moderately, and twenty-four slightly. There were, in addition, ten cases regarded as somewhat questionable, though there is

no clear demarcation between these cases and those of the group of workers slightly affected.

Case Reports

Case 12. *History.* — This employee, an Irishman, married, aged 48, had done blocking for twenty years, and during the year previous to this examination had done sizing. He gave a history of heavy drinking formerly, and of heavy use of tobacco at the time of examination. He stated that a Wassermann test made four years previously had been negative.

His vision was failing, but he wore no glasses. His hearing was normal, and he did not complain of tinnitus. He said that he had an occasional headache and frequent toothache, but had noticed no salivation nor metallic taste, nor dryness of the mouth, nor sore throat. He complained of no cardiorespiratory symptoms except slight dyspnea. He gave no history of edema. His appetite was good, and his digestion normal. He said that he had diarrhea occasionally but was never troubled with constipation. He had had nocturia only rarely.

Physical Examination.—He was a robust, stout man of ruddy complexion. His pupils were slightly irregular and reacted poorly to light. The muscles of the orbits showed a slight tremor, and there was twitching of the lips. His teeth were in poor condition and his gums showed marked gingivitis. There were small light plaques on the buccal mucosa. There was slight tremor of the tongue, but no coating. There was no adenopathy. Examination of the lungs, heart, and abdomen was negative. The pulse was 68.

Marked tremor of the fingers was noticed, together with intention tremor. The flexor and extensor muscles of the forearms were powerful. No changes in skin sense were noted. Knee jerks were present and Romberg test was negative. The palms of the hands were calloused and there was contraction of the right fourth finger, relative to which the man gave a history of injury in childhood.

The man said that he was readily irritable and felt blue. Previous to treatment for "kidney trouble," three months before the present examination, he had had attacks of dizziness. The urine showed a slight trace of albumin. Systolic blood pressure was 168; diastolic, 98.

X-ray examination disclosed a moderate degree of hilus infiltration, with somewhat increased density in the upper lobes of the lungs.

Case 41. *History.*—This man, a Czecho-Slovakian, married, aged 46, had done sizing for fifteen years. He said that he had drunk wine and used much tobacco. He had been troubled with watering eyes, and had worn glasses for five years. He gave a history of hemicrania for many years, but gave no history of vomiting. He did not report deafness but said that he had noticed tinnitus, accompanied by headache. For two months previous to this examination he had noticed a metallic taste "like rusty iron," and for two years had had salivation. He gave no history of dryness of the mouth or soreness of the tongue. He complained of moderately frequent colds, and of slight coughs with much sputum. He did not report hemoptysis, however. There was no history of dyspnea or palpitation, or of edema. He complained of poor appetite and eructations, and of diarrhea, and said that for two months he had had ten movements a day. For two years he had had a slight pain in the right hypochondrium, and during that time had lost 10 pounds in weight.

Physical Examination.—The man was pallid in appearance. There was nothing abnormal about the pupillary reactions or about the muscles of the orbit. His gums showed a blue line, and he said that they bled with brushing. The mucosae were normal. His tonsils were large and protruding. No tremor or coating of the tongue was noted. There was marked adenopathy.

Examination of the lungs disclosed evidences of an old process at the right apex, probably tuberculosis. No X-ray was obtained. Examination of the heart gave negative results. The pulse was 80. The vessel walls were found to be moderately thickened. There is some question whether the liver edge was palpable.

Tremor of the fingers, together with intention tremor, was observed. No muscle twitching was recorded. The flexor muscles of the forearms were powerful; the extensors were less strong. No sensory changes were noticed. Knee jerks were present, and the Romberg test was negative. Systolic blood pressure was 186; diastolic, 110.

The man complained of a pain in the fourth right metacarpal phalangeal joint. He had marked calluses on both palms, and slight Dupuytren's contractions of the fourth and fifth fingers of the right hand. He said that he was nervously irritable, had attacks of trembling, and was embarrassed by the presence of strangers in the shop. He admitted

a feeling of discouragement. He gave a history of attacks of dizziness, marked insomnia, and of being readily fatigued.

CASE 50. *History.*—This man was a German, married, aged 64, who had done sizing for forty years. He gave a history of typhoid fever forty-three years previous to this examination. He said that he had drunk beer, and had used tobacco moderately. He denied having had venereal disease.

His vision was fair; he had worn glasses for reading for ten years. He gave no history of deafness or of headaches, but complained of continued tinnitus. His teeth were all out; he said that they had been loose for four or five years. He had not noticed any metallic taste, salivation, dryness of the mouth, or soreness of the tongue or throat. His speech was defective because he was "so nervous." He had had no respiratory symptoms, and no dyspnea nor palpitation. He reported marked edema of the legs. His appetite was good. He said that his bowels moved daily, and that after drinking milk he had diarrhea. For two years he had had moderate nocturia.

Physical Examination.—This man was of senile appearance. He had marked tremor and experienced great difficulty in unbuttoning his clothing. The movements of his hands resembled those of a mandolin player. His complexion was ruddy. His pupils reacted slightly to light. There was a rhythmic twitching of the muscles of the orbits, and quivering of the upper lip. He had no teeth. He said that his gums had bled formerly. The buccal mucosae were slightly blueish, and there was salivation. No tremor of the tongue was recorded. Examination of the lungs showed a slight increase of physiological signs in the right apex. His heart was normal. His pulse was 56. A slight thickening of the vessel walls was noticed. Examination of the abdomen gave negative results.

There was marked coarse tremor of the hands and arms, and quivering of the legs, which was strikingly increased when an effort was made to control the muscles in careful movements. There was marked fibrillary twitching. The flexors of the forearms were weak; the extensors were of normal power. The man complained of cramping sensations in the limbs, and of pain in the back. With the Romberg test the tremor subsided. He said that when he was excited he was almost unable to speak. He acknowledged feeling greatly discouraged and blue. He said that he sometimes had attacks of dizziness, which cleared quickly but which had once or twice caused him to fall. He said that he slept well; that he was often so fatigued by work that he "can hardly walk home." There was a slight Dupuytren's contraction of the fourth finger of both hands.

It was difficult to obtain his blood pressure because of the marked tremor of the arm. Systolic pressure was 130; diastolic, 84.

X-ray examination disclosed a slight increase of the hilus shadows within normal limits.

CASE 58. *History.*—This workman, an American of Irish parentage, a widower, aged 62, had been employed as a mixer in the blowing room for thirty-three years. He gave a history of scarlet fever in childhood, with subsequent partial deafness. He denied having had venereal disease.

He had worn glasses for twenty-five years. For one year previous to this examination he had had marked occipital headache and tinnitus. He complained of frequent toothache, and of soreness of the tongue, but gave no history of metallic taste, dryness of the throat. or sore throat. He said that he had noticed salivation, and that his pillow became stained from it. He stated that he had occasional colds and cough with sputum. He had noticed palpitation but no dyspnea nor cyanosis. He complained of edema of the feet in the morning. His appetite was good and he was not troubled with indigestion. His bowels moved with laxatives. He said that he had nocturia two or three times, and that occasionally he had hematuria.

Physical Examination.—This workman's skin was clear and pale, and he appeared to be fairly well nourished. He had one molar and many roots left. He had marked pyorrhea; his gums showed a dark line, but the markings were not punctate. The mucosa was cyanosed. There was a slight tremor of the tongue and a moderate coating. No adenopathy was recorded. Examination of the lungs gave negative findings. The heart was found to be enlarged toward the left side, and aortic second sound accentuated. The pulse was 124. Examination of the abdomen was negative.

There was marked tremor of the extremities, especially of the legs. Vertical oscillations were noted when he seated himself. He unbuttoned his clothing with ease, but found it difficult to touch the end of a pencil with his finger. About seven months previous to this examination he had left work because of the "shakes," and had been on crutches for three months. Fibrillary twitching was present. The power of the flexors of the forearms was fair; the power of the extensors, poor. The knee jerks were present; Romberg test was positive. He said that he had

noticed formication. Of late he had been somewhat discouraged and depressed. Following a quick movement he would become dizzy, and would almost fall. He said that he slept well.

Systolic blood pressure was 220; diastolic, 150. The urine showed a slight trace of albumin.

X-ray examination showed marked hilus infiltration, increased soft glands, and mottling scattered throughout both chests. The left upper lobe of the lung was distinctly dull. The findings resembled tuberculosis.

Summary

1. This article gives a presentation of the findings of the examinations of one hundred hatters' fur workers, hat makers, and finishers of varying ages, nationalities and occupations, most of whom considered themselves in reasonably good health.

2. A number of cases of heavy calluses of the hands and of Dupuytren's contraction were observed.

3. No cases of active tuberculosis were recognized. Radiographs of 56 per cent. of the group disclosed no notable incidence of serious pulmonary disease.

4. In 39 per cent. of the cases the systolic blood pressure was found to be abnormally high.

5. Certain accepted evidences of mercurialism, especially tremor and psychic irritability, were frequently encountered. Forty-three per cent. of the group were considered to be in some degree poisoned by mercury.

Grateful acknowledgment is made to Dr. Robert W. Hinds and Mr. Daniel N. Barber for assistance in the conduct of the examinations; to Dr. Herman Osgood, who served as roentgenologist; to the officers of the organized hatters of Danbury; and to the staff of the Industrial Clinic of the Massachusetts General Hospital for its aid in connection with the analysis of the material collected.

A NOTE ON THE SILICA CONTENT OF SOME FACTORY DUSTS *

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THE incidence of phthisis among boot and shoe makers is commonly known to be high, and various reasons have been put forward in explanation. Gold miners, masons, and other workers in silicious materials, however, have a much higher phthisis mortality, which has been shown to be due to the inhalation of silica dust (1). The inhalation of this dust is followed by a fibrous condition of the lungs, known as silicosis: this fibrosed lung in time becomes infected with the tubercle bacillus. Silicosis, however, can only be brought about by the inhalation of free silica, SiO_2; combined silica is without effect—clay which contains 50 per cent. or more silica is quite innocuous, the silica being combined with alumina. Obviously, then, it is free silica which must be looked for in industrial dusts; an analysis which simply gives the total silica content is useless. As silica is by no means an uncommon substance, industrial physicians may naturally harbor the idea that an excessive amount of silica may be present in the dust of boot and shoe factories, and may be the cause of the high phthisis rate in that industry.

Silicosis has also been advanced as a cause of printers' phthisis. Roos (2) investigated the dust from printers' workrooms and found small amounts of silica present, but less than in the dust of living rooms. He therefore concluded that silica was not responsible for printers' phthisis.

Through the kindness of Dr. R. Pratt of Leicester, an opportunity arose to investigate the dust from a large boot and shoe factory, and also from a hosiery factory, in that town. The hosiery industry, it should be noted, has not a high phthisis rate.

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Examination of Dust from Boot and Shoe, and Hosiery Factories

Of the samples of dust sent to the laboratory from the factories, most stress was laid on those which came from the roof beams and the blades of the exhaust ventilating fans. Microscopic examination of these samples showed, in every case, the presence of a few sharp-edged particles which were believed to be sand. The analyses, except that of the free silica, were carried out by standard methods. There is no very satisfactory chemical method of determining free silica in a mixture containing much combined silica, and a mechanical method of separation was therefore used, the dust being separated into various fractions by shaking with water and by partial sedimentation. By determining the total amount of silica in the various fractions, it was possible to calculate approximately the amount of free silica. A fraction containing 90 per cent. total silica, for example, necessarily consisted almost entirely of free silica. The other inorganic bodies present were largely iron and alumina.

Table 1 shows the results obtained from the analysis of the dust of the two factories investigated. It will be seen from this table that the dust from the "phthisis" boot and shoe factory con-

tained no more free silica than that from the "non-phthisis" hosiery factory. Probably the silica found was, for the most part, brought into the factory on the workers' boots.

By way of comparison with these results, some samples of dust from our laboratory shelves, etc., were analyzed and were found to contain 16 per cent. total silica and 7 per cent. free silica. Sir James Crichton-Browne found 21 per cent. silica in dust taken from the top of a wardrobe in a London house. There is, in fact, some silica in all dusts. This is not surprising, however, considering the wide distribution of the substance.

From the results of this investigation, it must be concluded that silica plays no part in boot and shoe makers' phthisis.

TABLE 1.—RESULTS OBTAINED FROM ANALYSIS OF DUST SAMPLES FROM BOOT AND SHOE, AND HOSIERY FACTORIES

Factory	Source of Dust	Composition of Dust			Phthisis Death Rate[1]
		Organic Matter	Total Silica	Free Silica	
		%	%	%	
Boot and Shoe[2]	finishing room: exhaust fan blades	62	10.4	3.0	235
Boot and Shoe	finishing room: beams	58	18.6	4.2	235
Boot and Shoe	floor sweepings: average of various rooms	51	18.4	5.1	235
Hosiery	winding room: beams	51	20.5	8.0	176
Hosiery	main producing room: exhaust fan blades	71	8.2	4.0	176
Hosiery	main producing room: beams	60	16.5	6.1	176

[1]Standardized mortality rates.
[2]A sample of leather dust from the finishing room showed only 0.17 per cent. total silica.

Summary

1. Pulmonary silicosis, the fore-runner of tuberculous-silicosis, follows only upon the inhalation of the dust of free silica.

2. Silica is not responsible for printers' phthisis.

3. The amount of free silica found in dust from a boot and shoe factory does not exceed that in dust from a hosiery factory, from a laboratory, or from a London house.

4. Evidence does not place the responsibility for boot and shoe makers' phthisis upon silica.

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A STUDY OF THE MORTALITY OF COAL MINERS, ENGLAND AND WALES

(Continued)

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RESUME OF POINTS FOR CONSIDERATION

1. There is a great diversity in the death rates on the various coal fields not fully accounted for by local non-industrial influences.

2. This diversity is mainly accounted for by the fact that the fields with higher death rates experience higher mortality rates from phthisis, pneumonia, bronchitis, and accidents.

3. The mortality from phthisis, while varying considerably on the different fields, is low on all fields.

4. Men at the coal face as life progresses suffer more from phthisis than others employed in the mining industry; the only exceptions are found in Monmouthshire and South Wales and in Nottingham where this occupational group suffers less than the other two groups.

5. Pneumonia is in excess on certain coal fields, notably in Lancashire.

6. The tendency is for pneumonia, when in excess, to affect men at the face, but an exception is found in Monmouthshire and South Wales and in Nottingham where this group suffers less from the disease than the other two groups.

7. There is a tendency for a high death rate from pneumonia among both groups of men employed under ground to be closely associated with a comparatively high death rate from phthisis.

8. Bronchitis also is found with a wide range of mortality rates which frequently exceed the standard, the excess being most pronounced where the mortality rates from phthisis and pneumonia are high.

9. Generally speaking, the tendency is for bronchitis, when in excess, to affect men at the face particularly late in life.

10. The accident rates are high on all coal fields, and the fields with high mortality rates from other causes experience high accident rates.

11. The outstanding feature of the accident mortality is the way in which it groups the fields in an order similar to that established by mortality from the respiratory diseases.

12. Others below ground succumb from accidents more than either of the other groups. Men at the coal face come second. On two fields where the accident rate is low—Nottingham, and Durham and Northumberland—the position is reversed.

13. Men at the face in Monmouthshire and South Wales in relation to the other two occupational groups of that field present an exception in that the mortality rates from phthisis, pneumonia, and accidents are all comparatively lower than on other fields.

DISCUSSION

The outstanding features of the points enumerated are (*a*) the way in which the four causes of death considered are

either all high or all low on any given coal field; (*b*) the way in which the relative position of the three occupational groups with respect to the four causes of death is maintained on the different fields; and (*c*) the fact that when an exception occurs, as in Monmouthshire and South Wales and in Nottingham, the tendency is for all four causes of death to be affected. The deductions follow that there must be some common factor or factors (1) which influence these four causes of death; (2) which vary in intensity on the different fields; (3) which exert a cumulative effect increasing in power with length of occupation; (4) which affect men at the face more than others; but (5) which in Monmouthshire and South Wales affect men at the face less than others.

Phthisis and Respiratory Diseases

Special consideration may first be given to the mortality from phthisis because something is known of the influences which determine it.

Phthisis, or pulmonary tuberculosis, is an infectious disease transmitted from person to person. Its prevalence is influenced by (*a*) aggregation of individuals, which increases opportunities for passing on infection; (*b*) general personal health or power of resisting infection; and (*c*) exposure to the inhalation of silica dust, which has a peculiar capacity for sensitizing the tissues to tuberculous infection.

(*a*) Coal mining does not bring workers together as do industries like tailoring, bootmaking, and printing, in which phthisis is unduly prevalent; nor is there any marked difference between the aggregation of workers on the different coal fields, or in the different occupational groups considered. This influence, if it plays any part in this industry, may be a contributory influence determining why the industry as a whole experiences a low mortality from the disease.

(*b*) An important industrial influence affecting health is ventilation, and if the South Wales field were unique in employing the longwall method of coal getting in which the man at the face gets better ventilation than in the pillar and stall method, this influence might account for the phenomena noted; but in fact this is not so. There is no reason for supposing that the general personal health of workers on the various fields or among the various occupational groups on the same field differs in a way which would account for the facts.

(*c*) The question of the inhalation of silica dust calls for careful consideration. The coal measures, particularly the strata intervening between the coal seams, are known to contain definite amounts of silica, the dust of which, when inhaled, has been shown to set up in the lungs a form of fibrosis known as silicosis. Persons with silicosis are particularly liable to succumb to pulmonary tuberculosis, and then their deaths are ascribed simply to phthisis.

TABLE 16.—MEDIAN AGE AT DEATH FROM PHTHISIS AMONG COAL MINERS, AGED 15 YEARS AND OVER, DISTRIBUTED ACCORDING TO OCCUPATION [1]

Coal Field	Workers at Face	Others below Ground	Workers above Ground
Nottinghamshire	30	28	24
Derbyshire	35	19	30
Northumberland and Durham	34-35	26-27	24
Monmouthshire and South Wales	37	37-38	40-41
Staffordshire	36	22-23	34
Yorkshire	41	21	27
Lancashire	42	32	29
England and Wales..	37-38	30-31	31

[1] The data of this table have not been standardized for age distribution of the occupational groups.

TABLE 17.—MEAN ANNUAL DEATH RATE OF COAL MINERS FROM BRIGHT'S DISEASE[1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	0.152	0.150	0.085	0.209	0.435	1.795	2.755	2.137	0.403	0.37
Lancashire	0.139	0.049	0.098	0.315	0.398	1.753	3.152	2.874	0.442	0.38
Yorkshire	0.223	0.060	0.103	0.248	0.289	1.229	2.876	1.787	0.322	0.32
Derbyshire	0.141	– –	0.058	0.281	0.695	1.053	4.826	– –	0.379	0.37
Nottinghamshire	– –	– –	0.126	0.173	0.100	1.382	1.605	– –	0.223	0.21
Staffordshire	– –	0.133	0.063	0.163	0.323	0.474	0.812	3.195	0.219	0.18
Monmouthshire and South Wales	0.012	– –	0.045	0.125	0.337	1.254	1.816	0.736	0.157	0.21
Other districts	0.093	0.042	0.112	0.214	0.264	0.884	3.911	4.357	0.354	0.31
England and Wales (all districts)	0.053	0.051	0.081	0.210	0.362	1.306	2.731	2.161	0.301	0.29
(b) Other Workers below Ground										
Northumberland and Durham	0.011	0.075	0.082	0.063	0.196	0.475	1.939	8.081	0.158	0.19
Lancashire	– –	0.049	– –	0.132	– –	0.761	– –	5.747	0.078	0.11
Yorkshire	0.041	0.048	– –	0.218	0.122	0.934	0.693	– –	0.101	0.15
Derbyshire	– –	– –	– –	– –	0.757	0.631	8.714	– –	0.186	0.36
Nottinghamshire	– –	– –	– –	0.392	0.571	0.901	3.175	– –	0.170	0.29
Staffordshire	– –	0.127	– –	– –	0.263	0.462	– –	10.416	0.088	0.13
Monmouthshire and South Wales	– –	0.120	0.037	0.174	0.390	0.795	2.349	6.116	0.235	0.25
Other districts	0.057	– –	– –	– –	0.203	– –	1.768	5.555	0.099	0.11
England and Wales (all districts)	0.016	0.070	0.032	0.125	0.250	0.607	1.835	5.964	0.150	0.19
(c) Workers above Ground										
Northumberland and Durham	0.063	– –	0.083	– –	0.288	0.941	0.418	12.821	0.231	0.20
Lancashire	– –	– –	– –	– –	0.225	1.479	0.733	7.407	0.264	0.18
Yorkshire	– –	– –	0.109	0.136	0.547	1.120	1.961	6.289	0.316	0.28
Derbyshire	– –	– –	– –	– –	– –	0.487	2.835	– –	0.197	0.11
Nottinghamshire	– –	– –	– –	– –	– –	0.687	1.488	– –	0.147	0.08
Staffordshire	0.231	– –	– –	– –	0.355	– –	3.003	– –	0.247	0.16
Monmouthshire and South Wales	– –	– –	– –	0.305	0.278	1.580	3.106	– –	0.397	0.28
Other districts	– –	– –	– –	– –	– –	0.038	4.762	– –	0.081	0.13
England and Wales (all districts)	0.039	– –	0.037	0.090	0.258	0.958	1.700	4.016	0.258	0.19

[1]For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

The suggestion that tuberculous silicosis may account for the diversities in the prevalence of phthisis found among coal miners—even though it may be considerably less common among coal miners than among tin miners, stone masons, and others—necessitates reference to this disease. The Royal Commission on Metalliferous Mines and Quarries, when discussing this disease, summarizes the question in these words:

> If in any class a high death rate from pulmonary tuberculosis is found occurring at a later period of life than is usual for pulmonary tuberculosis, and if this high death rate is associated with a high death rate from other respiratory diseases, then this class is exposed to the inhalation of injurious dust.

The first criterion, then, is that the disease must occur at a later period of life than is usual. A simple effort to test this point is shown in Table 16. Although the data given in this table cannot be taken as more than suggestive, owing to the complication of unequal age distribution in the occupational groups on the different fields, the tendency displayed is for men at the face (who have been found to suffer most from phthisis), when dying of phthisis, to be distinctly older than members of either of the other occupational groups; for this difference to be most pronounced on the fields where phthisis is most prevalent; and for this difference not to be found in Monmouthshire and South Wales. So far, then, as the data may be relied upon, the records stand the first test.

The second criterion associates the death rate from pulmonary tuberculosis with a high death rate from other respiratory diseases. The examination of mortality data already made has shown that the prevalence of phthisis varies on the different fields with the prevalence of the other respiratory diseases, pneumonia and bronchitis; and, further, that the same thing holds good for the occupational groups concerned. The second test also is thus complied with.

While the suggestion put forward may explain the unequal distribution of phthisis on the coal fields, it does not necessarily cover the whole case in regard to "other respiratory diseases," including pneumonia and bronchitis. These diseases may result from other causes than exposure to silica dust, as, for instance, from exposure to other insoluble dusts arising from basalts and the like, or to sudden changes of temperature due to keen drafts in the main ingoing air ways, or on the surface. Prevalence of "other respiratory diseases," not associated in any way with the prevalence of phthisis, may be due to such causes; but from the series of mortality data now under consideration no definite conclusions as to the influence of such exposures can be drawn.

If investigation should prove that coal on the South Wales field either contains but little silica, or is got by the man at the face with a minimum disturbance of the intervening strata; and that in the Derbyshire and Nottinghamshire fields the amount of silica present in the coal measures is less than on the other fields, we should be justified in holding exposure to dust inhalation to be an important influence underlying the diverse mortality rates from phthisis, pneumonia, and bronchitis, found to exist on the different fields.

Bright's Disease

There still remains a further statistical test: Occupational groups exposed to the inhalation of silica dust have been noted to experience, in addition to an excessive mortality from phthisis and other respiratory diseases, a high mortality from Bright's disease, which may

be attributed to the same cause. The number of deaths occurring from this disease among coal miners, when distributed by coal field and occupation, is too small to furnish reliable death rates; hence small differences in the standardized death rates must not be depended upon. Further, the death rate from phthisis among coal miners, which is uniformly low, suggests that if silica dust exerts any influence, this influence is not a powerful one—in other words, the amount of silica inhaled must be small; or, that there is present some counteracting influence minimizing the tendency of silica dust to pave the way for tuberculous infection, which influence may or may not counteract the tendency of silica to affect the kidneys.

Nevertheless, the deduction may be drawn from the data of Table 17 that some relation exists between the death rates from phthisis and from Bright's disease. Thus, workers at the face on all coal fields, who experience more phthisis than the other two occupational groups, are also found suffering a higher mortality from Bright's disease. When the separate coal fields are considered, however, the death rates from Bright's disease among men at the face are found to fall into two groups; one group, which includes Lancashire, Durham and Northumberland, Derbyshire and Yorkshire, stands above and distinct from the other group, which includes Nottinghamshire, South Wales, and Staffordshire. The first group of four includes three fields —*i.e.*, Yorkshire, Lancashire and Durham, and Northumberland, which, for

TABLE 18.—AVERAGE DEPTHS OF WORKINGS IN COAL FIELDS OF UNITED KINGDOM (BASED ON DEPTHS OF SHAFTS)

Division	Coal Field	Average Working Depth
		Feet
Northern Division	Cumberland	900
	Durham	800
	Northumberland	400
York and N. Midland Division	Derbyshire	922
	Nottinghamshire	1,223
	Yorkshire	1,220
Lancashire, N. Wales and Ireland Division	Cheshire	420
	Lancashire	1,500
	Denbigh	1,020
	Flint	450
	Ireland	135
South Wales Division	South Wales and Monmouth	1,650
Midland and Southern Division	Bristol	1,290
	Derbyshire (South)	690
	Forest of Dean	750
	Kent	1,050
	Leicester	660
	Shropshire	750
	Somerset	1,080
	Staffordshire — North	1,560
	Staffordshire — South	420[1]
	Staffordshire — Cannock Chase	900
	Warwick	1,500

[1] This average is apart from three of the largest pits—namely, Hamstead 2,100 feet deep; Sandwell Park 2,340 feet deep; and Baggeridge 1,950 feet deep.

this group of workers, stood highest in phthisis mortality; while the lower group of three includes two fields, Nottinghamshire and South Wales, which stood lowest.

For others below ground the only notable point is that for Nottinghamshire and South Wales, where the phthisis mortality of this occupational group was found to be unusual in being higher than that among men at the face, the mortality from Bright's disease follows the same course.

Probably this is as far as the available data permit this test to be applied, and all that can be said is that the test is not unfavorable to the suggestion that exposure to dust of silica may exert an influence on the mortality from respiratory diseases among coal miners.

Accidents

The causation of accidents in mines, since it is known, may be expected to throw some light on the whole matter. Two kinds of accidents, explosions and falls of ground, are peculiar to the mining industry. Explosions which lead to great disasters are fortunately sufficiently exceptional to permit them to be disregarded for the moment, although the presence in the workings of gases which give rise to these explosions cannot be quite disregarded in view of the somewhat remote possibility of these gases affecting the worker's health when inhaled over long periods of time. The other most distinctive cause of mining accidents is falls of ground — a cause which, in 1911, a year in which there was no great disaster, was responsible for 50.4 per cent. of all accidents on English and Welsh coal fields. Falls of ground mainly concern men at the face, and other forms of accidents concern the other workers; but since there are more men employed at the face than elsewhere (510,282 in all districts, compared with 350,549 for others below ground and workers above ground taken together[3]), the accident rate so caused is comparatively low for this occupational group. Dust rising from falls of ground can hardly be looked upon as being generated sufficiently frequently to be the origin of that dust, the inhalation of which is suggested to account for the prevalence of respiratory diseases; but if coal in measures underlying sandy shales contains more silica than coal underlying a good sandstone roof, then some explanation of the relation found to exist between the different mortality data would be forthcoming. Falls of ground depend upon two main causes: (1) the nature of the strata overlying the coal measure being worked; and (2) the amount of cover—*i.e.*, the depth of the workings.

1. Information as to the strata overlying coal measures, particularly in relation to chemical composition, is needed.[4]

2. The average depths of the mines on the different fields have been recently obtained by the Mines Department, and are given in Table 18.

General Theory

On the theory now proposed, death rates from respiratory diseases would be related to the silica content of the coal worked, and also of the roof. Falls of ground are related to the composition of the roof and to the depth of the workings. On this theory, in South Wales and Nottingham, there should be little

3. See also page 261 relative to number of men employed above ground.

4. I understand that in South Wales on parts of the field the roof is formed of sandstone, the Pennant seam, which provides a fairly stable roof; but on other coal fields sandy shales more frequently form the roof..

silica in the coal, and a good sandstone roof; this roof should be ripped by a group of men (included among others below ground), who, being thus exposed to injurious dust, suffer more from phthisis, pneumonia, and bronchitis. In Yorkshire the coal should contain some silica, but the roof should be of shales. In Lancashire coal should contain rather less silica than the coal in Yorkshire, but the roof should be of a rather insecure sandstone. In Derbyshire there should not be much silica in the coal or in the roof (unless there is very little roadripping). The mortality for Durham and Northumberland is stated together, but the Durham field appears, from the depth of the workings, to differ from the Northumberland field; similarly, the various parts of Staffordshire (mortality for which is given as a whole) differ considerably in the workings; no suggestions are, therefore, hazarded as to the geology of these fields.

BOOK REVIEW

PULLING TOGETHER. By *John T. Broderick*. Cloth. Pp. 141 and introduction and table of contents. Schenectady, N. Y.: Robson & Adee, 1922.

To say that the 141 pages of "Pulling Together" cover the field of industrial relations, could not, of course, be true. There is a marked tendency to stress the problem of employee representation, and other questions which are introduced group themselves, for the most part, around this central idea. The discussion is, as might be expected, quite sketchy. The writer displays a naïve zest for his subject which would make the book appeal primarily to the layman.

The text of the book is developed in the form of a conversation which is represented as taking place between the writer, a salesman and the president of a well-known corporation. The reader is unfortunately impressed at the outset with a lack of reality in the setting, which weakens the writer's natural tendency to express things well. The issues involved are serious ones. If the president of any influential corporation was actually a party to the conversation of the text, this fact should not be left in doubt; if the situation was fictitious, it seems as if, just at this time, the writer is taking an unfortunate liberty which makes the reader resentful, even against his will.

Aside from this regrettable defect in structural conception many things are said well. There is apparently no attempt to add to current thought on the questions involved. Those who know little of the current problems of industrial relations will do well to consider the writer's arguments. That industrial organization is at present viewing its problems of industrial relations from exactly the same angle as that of the writer is not to be determined here. It is true, however, that among our most progressive industries there has been a marked tendency in the last few years to adopt as a working hypothesis the fundamentals which he advocates.—*C. H. Paull.*